CLAIMS

Having described the preferred embodiments, the invention is now claimed to be:

1. A magnetic field gradient coil for a short-bore magnetic resonance imaging scanner, the gradient coil comprising:

upper and lower magnetic field gradient coil windings (70, 72, 74, 76, 102, 104, 112, 114) that define a subject-receiving bore (44) and which generate transverse magnetic field gradients imposed on an associated static magnetic field generally oriented in a longitudinal direction through the bore, the upper gradient coil winding (70, 74) having an arcuate curvature (C_{upper}) transverse to the longitudinal direction and a longitudinal length (L_{upper}) in the longitudinal direction that is smaller than a longitudinal length (L_{lower}) of the lower gradient coil winding (72, 76).

2. The gradient coil as set forth in claim 1, further including:

a coil support including an upper section (40) supporting the upper magnetic field gradient coil winding (70, 74) and a lower section (42) supporting the lower magnetic field gradient coil winding (72, 76).

3. The gradient coil as set forth in claim 2, wherein the upper and lower magnetic field gradient coil windings (70, 72, 74, 76) include:

primary coil windings (70, 72) disposed on coil bore-defining surfaces (52, 56) of both the upper and lower sections (40, 42) of the coils support; and

shield coil windings (74, 76) disposed on outer surfaces (50, 54) of both the upper and lower sections (40, 42) of the coils support.

4. The gradient coil as set forth in claim 3, further comprising:

connecting conductors (82) extending across an edge (62) of the lower section (42) between the coil bore-defining surface (56) and the outer surface (54), the connecting conductors (82) electrically connecting the primary and shield coil windings (72, 76).

5. The gradient coil as set forth in claim 1, wherein::

the arcuate curvature of the upper gradient coil windings (70, 74) lies generally along a portion of a circular or oval cross-section; and

the lower gradient coil windings (72, 76) include primary windings (72) that are substantially planar compared with the arcuate curvature (C_{upper}) of the upper gradient coil windings (70, 74).

6. The gradient coil as set forth in claim 5, wherein the lower gradient coil windings (72, 76) further include

shield coil windings (76) lying generally along an arcuate curvature matching the arcuate curvature (C_{upper}) of the upper coil windings (70, 74) such that the upper gradient coil windings (70, 74) and the shield coil windings (76) of the lower gradient coil windings (72, 76) have one of a circular cross-section and an oval cross-section.

7. The gradient coil as set forth in claim 6, wherein the upper coil windings (70, 74) further include:

primary coil windings (70) and shield coil windings (74) each defining curved surfaces having the arcuate curvature (C_{upper}), the defined curved surfaces being spaced apart a separation distance transverse to the longitudinal direction;

connecting conductors (80) disposed at longitudinal ends of the upper coil windings (70, 74) and electrically connecting the primary coil windings (70) and the shield coil windings (74) by spanning the separation distance along a flared annular connecting surface (60) having an angle other than 90° respective to the longitudinal direction.

- 8. The gradient coil as set forth in claim 1, wherein the longitudinal length (L_{upper}) of the upper gradient coil windings (70, 74) is about the same as or less than a dimension of the coil bore (44) transverse to the longitudinal direction.
- 9. The gradient coil as set forth in claim 8, wherein a ratio of the longitudinal length (L_{upper}) of the upper gradient coil windings (70, 74) to the dimension of the coil bore (44) transverse to the longitudinal direction is less than or about 0.7.
- 10. The gradient coil as set forth in claim 1, wherein the magnetic field gradient coil windings (70, 72, 74, 76) include:

a first sub-set of the windings that when energized produce a first magnetic field gradient oriented transverse to the longitudinal direction and parallel to a plane of bilateral symmetry (58) of the gradient coil windings (70, 72, 74, 76); and

a second sub-set of the windings that when energized produce a second magnetic field gradient oriented transverse to the longitudinal direction and transverse to the plane of bilateral symmetry (58) of the gradient coil windings (70, 72, 74, 76).

- 11. The gradient coil as set forth in claim 10, wherein the first magnetic field gradient has a zero-field point (86) displaced toward the upper gradient coil winding (70, 74) relative to an imaging volume (16) that is surrounded by the gradient coil.
- 12. The gradient coil as set forth in claim 1, wherein the magnetic field gradient coil windings (102, 104, 112, 114) include:
- a first sub-set (102, 104) of the windings that when energized produce a magnetic field gradient (106) in a first direction oriented transverse to the longitudinal direction and at a 45° angle to a plane of bilateral symmetry (58) of the gradient coil windings (70, 72, 74, 76); and
- a second sub-set (112, 114) of the windings that when energized produce a magnetic field gradient in a second direction transverse to the longitudinal direction and transverse to the first direction.
 - 13. A magnetic resonance imaging scanner comprising:
- a housing (10) having: (i) an imaging volume (16) imaged by the scanner and (ii) an imaging subject support section (20) disposed below the imaging volume (16), the imaging subject support section (20) extending beyond a length (L_{bore}) of a magnet bore;
- a radio frequency coil (28) arranged to inject a radio frequency signal into the imaging volume (16); and
- a magnetic field gradient coil (30, 100) including a lower section (42) disposed in the imaging subject support section (20) of the housing (10) and an upper section (40) that together with the lower section (42) define a coil bore (44) containing the imaging volume (16), the upper section (40) having an arcuate curvature (C_{upper}) and coil windings (70, 74) spanning a first length (L_{upper}), the lower section (42) having coil windings (72, 76) spanning a second length (L_{lower}) greater than the first length (L_{upper}).

14. The imaging scanner as set forth in claim 13, wherein the coil windings (70, 72, 74, 76) of the magnetic field gradient coil (30) include:

- a first set of windings that when energized produce a vertical magnetic field gradient imposed on an associated generally horizontal magnetic field at least in the imaging volume (16).
- 15. The imaging scanner as set forth in claim 14, wherein the vertical magnetic field gradient has a zero-field point (86) displaced vertically upward relative to the imaging volume (16).
- 16. The imaging scanner as set forth in claim 14, wherein the magnetic field gradient coil windings (70, 72, 74, 76) further include:
- a second set of windings that when energized produce a horizontal magnetic field gradient imposed on the associated generally horizontal magnetic field at least in the imaging volume (16).
- 17. The imaging scanner as set forth in claim 13, wherein the magnetic field gradient coil windings (70, 72, 74, 76) when energized produce one or more magnetic field gradients imposed on an associated generally horizontal magnetic field at least in the imaging volume (16), the magnetic field gradient coil windings including at least:
- a first set of windings (102, 104) that when energized produce a first magnetic field gradient (106) oriented at a 45° angle to the horizontal; and
- a second set of windings (112, 114) that when energized produce a second magnetic field gradient (116) oriented at a 45° angle to the horizontal and oriented transverse to the first magnetic field gradient (106).
- 18. The imaging scanner as set forth in claim 13, wherein the second length (L_{lower}) spanned by coil windings of the lower section (42) is greater than the bore length (L_{bore}).
- 19. The imaging scanner as set forth in claim 13, wherein the radio frequency coil (28) includes:
- a generally planar lower section (28_1) disposed in the imaging subject support section (20) of the housing (10); and

an arcuate upper section (28₂) that together with the lower section (28₁) define a radio frequency coil bore contain the imaging volume (16).

20. A method of magnetic resonance imaging, the method comprising: generating a main magnetic field through a subject receiving bore (14); generating magnetic field gradients across the bore (14) with a combination of (i) upper gradient coils (70, 74) that have a first longitudinal length (L_{upper}) shorter than a diameter (D_{bore}) of the bore (14) and (ii) lower gradient coils (72, 76) that have a second longitudinal length (L_{lower}) longer than the diameter of the bore (14).